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Forest Health Protection

Pacific Southwest Region
Northeastern California Shared Service Area

Date: March 24, 2016
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To: District Ranger, Beckwourth Ranger District, Plumas National Forest

Subject: Evaluation of stand conditions at Cradle Valley (FHP Report NE16-04)

Summary

At the request of Paul Czeszynski, Silviculturist, Beckwourth Ranger District, Danny Cluck, Forest Health Protection (FHP) Entomologist conducted a field evaluation of the Cradle Valley project on March 23, 2016. The objective of this visit was to evaluate the current forest health conditions within the proposed project area, discuss what influence these conditions would have on stand management objectives, discuss the use of the 2014 Farm Bill categorical exclusion and provide recommendations as appropriate. Paul Czeszynski and Kasandra Meyers, Sales Prep Forester, accompanied me to the field.

Key findings:

- Overstocking is putting many stands at risk to high levels of bark beetle-caused tree mortality during periods of drought.
- Mixed conifer stands and Jeffrey pine stands have become denser with a higher proportion of white fir in the absence of fire.
- Many stands have experienced high levels of white fir mortality during current and recent droughts.
- Dwarf mistletoe infection levels are high in some Jeffrey pine stands reducing tree vigor and predisposing trees to bark and woodboring beetle attacks.
- High fuels loads, consisting of an abundance of dead-down trees and a dense understory of live trees have put many stands at risk to stand replacing wildfire.
- Thinning is highly recommended throughout the Cradle Valley area to reduce stocking of all tree species with an emphasis on the reduction of white fir and dwarf mistletoe infested Jeffrey pine.

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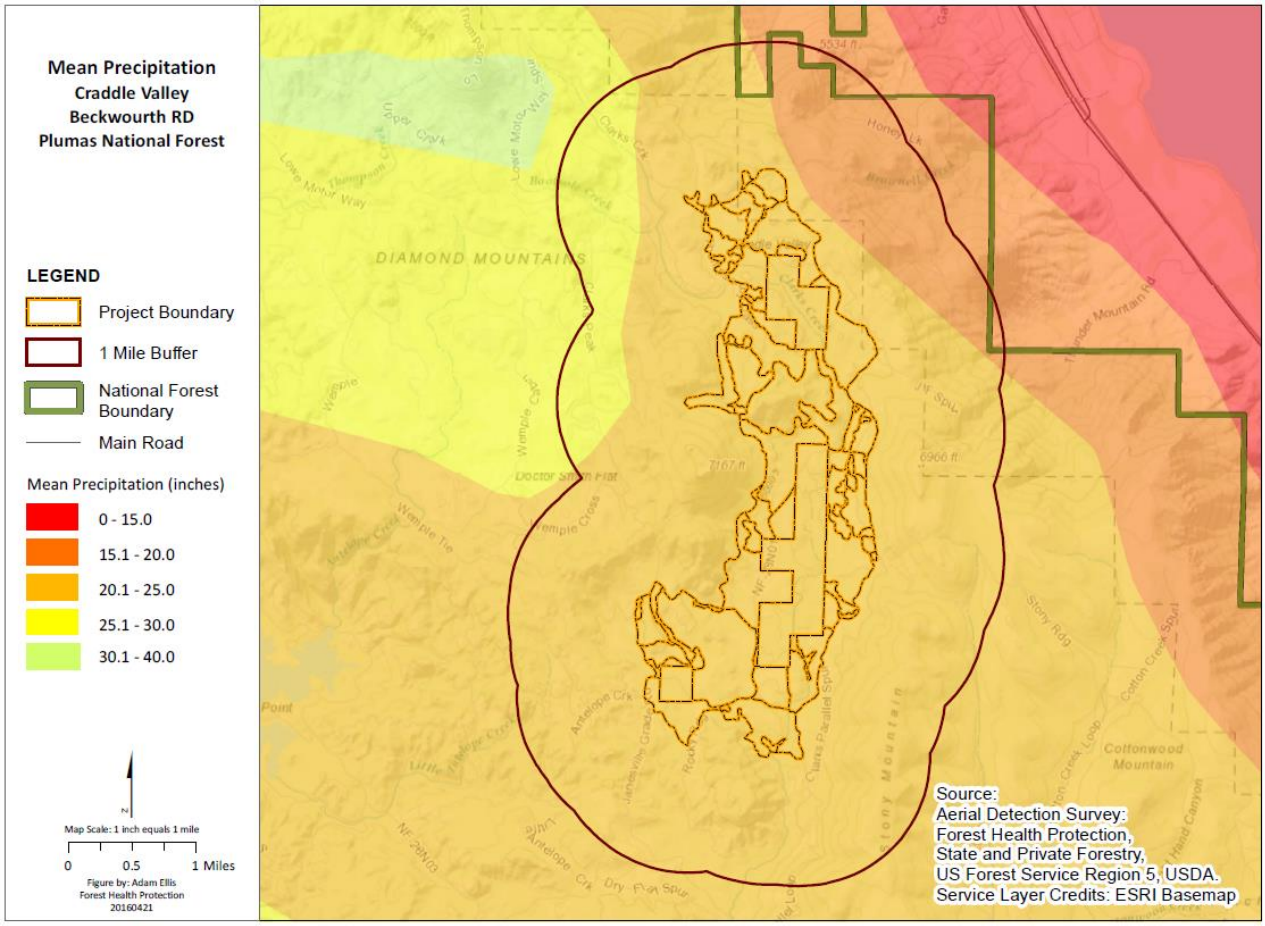
Description of the project area

The Cradle Valley project is located approximately 6 miles south of Janesville, CA at elevations ranging between 5,800 and 6,500 feet (40.212731N and 120.498998W). Annual precipitation ranges between 20 and 25 inches (Figure 1). Jeffrey pine (*Pinus jeffreyi*) stands dominate the project area but most have a white fir (*Abies concolor*) component. Sierra mixed conifer is found in a couple of locations within the project area, consisting of white fir, Jeffrey pine, ponderosa pine (*Pinus ponderosa*) and incense cedar (*Calocedrus decurrens*). Lodgepole pine (*Pinus contorta var. murrayana*) exists in and adjacent to riparian areas often competing with quaking aspen (*Populus tremuloides*).

Figure 1. Mean annual precipitation for Cradle Valley and surrounding area.



Project objectives

The Cradle Valley project proposes to improve forest health through thinning of mostly smaller diameter trees, grapple piling down woody debris and prescribed burning. Jeffrey pine stands will be thinned to approximately 60 - 80 sq. ft./acre of basal area. Mixed conifer stands will retain relatively higher stocking based on local site conditions. The residual stands will be more open, increasing the amount of available soil moisture and sunlight for individual trees, and contain fewer white fir. This project will increase the resiliency of treated stands to bark beetles and dwarf mistletoe. The project will be accomplished using the 2014 Farm Bill categorical exclusion.

Forest insect and disease conditions

Agents/hosts observed:

- Pockets of severe western dwarf mistletoe (*Arceuthobium campylopodum*) infections on Jeffrey pine
- White fir dwarf mistletoe (*Arcuethobium abietinum*) infections on white fir
- Fir engraver beetle (*Scolytus ventralis*)-caused mortality of white fir
- Heterobasidion root disease (*Heterobasidion occidentale*) in white fir
- California flatheaded borer (*Phaenops californica*) attacks on dwarf mistletoe infected Jeffrey pine

Stand conditions and mortality related to recent and future climate trends

Many of the forested areas in the Cradle Valley area are in an overstocked condition and in drier years have exhibited an elevated level of tree mortality caused by bark beetles (and occasionally woodboring beetles) (Table 1 and Figure 2). This mortality combined with high stand density has resulted in heavy fuel loading in some areas and a corresponding increase in fire danger.

There are Jeffrey pine stands within the project area that were thinned in past but residual stocking after treatment was higher than is recommended to reduce the risk of bark beetle-caused mortality. These stands have also increased in density since they were treated and are currently at an elevated risk to Jeffrey pine beetle. The latest peer-reviewed research on Jeffrey pine stocking as it relates to Jeffrey pine beetle-caused mortality (Egan et al 2016) and a FHP report for the same study (Egan et al 2009) suggest stocking levels that are at or below SDI 210 (corresponded to < 125 sq.ft./acre of basal area in study plots) to reduce tree mortality during droughts and high bark beetle population pressure. Stocking levels of SDI 110 (corresponded to <80 sq.ft./acre of basal area in study plots) had no Jeffrey pine beetle-caused mortality during the Jeffrey pine beetle outbreak monitored during the study.

Table 1. Acres with mortality, estimated dead trees per acre and estimated total # of dead trees from R5 Aerial Detection Surveys and Palmer Hydrologic Drought Index (PHDI) (average of CA Divisions 2 and 3[1]) by water year (Oct-Sept) within and adjacent to the Cradle Valley area.

Year	Acres	Dead Trees/Acre	Total # of Dead Trees	PHDI[2]
2015	265	1.7	438	-3.34
2014	31	1.4	44	-3.56
2013	40	2.6	106	-2.16
2012	159	1.4	220	-0.59
2011	668	1.8	1,227	2.78
2010	1,565	2.8	4,354	-0.14
2009	1,093	2.5	2,752	-2.98
2008	1	9.7	6	-3.16
2007	Not Available	Not Available	Not Available	-3.17
2006	56	7.3	415	2.40
2005	208	0.5	104	0.37

[1] California Divisions 2 and 3 encompass most of northeastern California. Cradle Valley is on the border between these two zones.
[2] PHDI values ranging from -2.00 to -2.99 are considered moderate drought conditions. Severe drought conditions range from -3.00 to -3.99 and extreme drought conditions are below -4.00.

White fir that succumb to fir engraver beetle attacks are typically predisposed by other factors that compromise their health and vigor. In the Cradle Valley area, high stand density, prolonged drought, trees growing off site, dwarf mistletoe and Heterobasidion root disease are all contributing factors in declining tree health and mortality. All of the Cradle Valley project area is within the 20-25" annual precipitation zone. This level of annual precipitation puts white fir in the "extreme risk" of mortality category (D. Schultz 1994, FHP Report 94-2). Therefore, even with lower stocking levels, trees can still be vulnerable to moisture stress and subsequent bark beetle attacks.

> Extreme risk: 20-25 inches of annual precipitation (100% of Cradle Valley project area). In some cases the shade tolerant white fir may live long enough to achieve an intermediate or co-dominant crown position. Prolonged drought may cause mortality of 80-85% of the stems. In stands where the total stocking of both overstory and understory is high, mortality may also occur in the pines. The risk of mortality may be lowered by managing groups of pine at wide spacing.

The current trend in most Cradle Valley stands of increasing stand density, high levels of insect and disease activity and elevated levels of mortality are likely to continue until a major disturbance event such as a stand replacing fire occurs. Jeffrey pine beetle and fir engraver beetle activity is likely to increase in response to extended drought periods.

Figure 2. Areas of elevated tree mortality mapped by Aerial Detection Surveys (ADS) between 2000 and 2015.

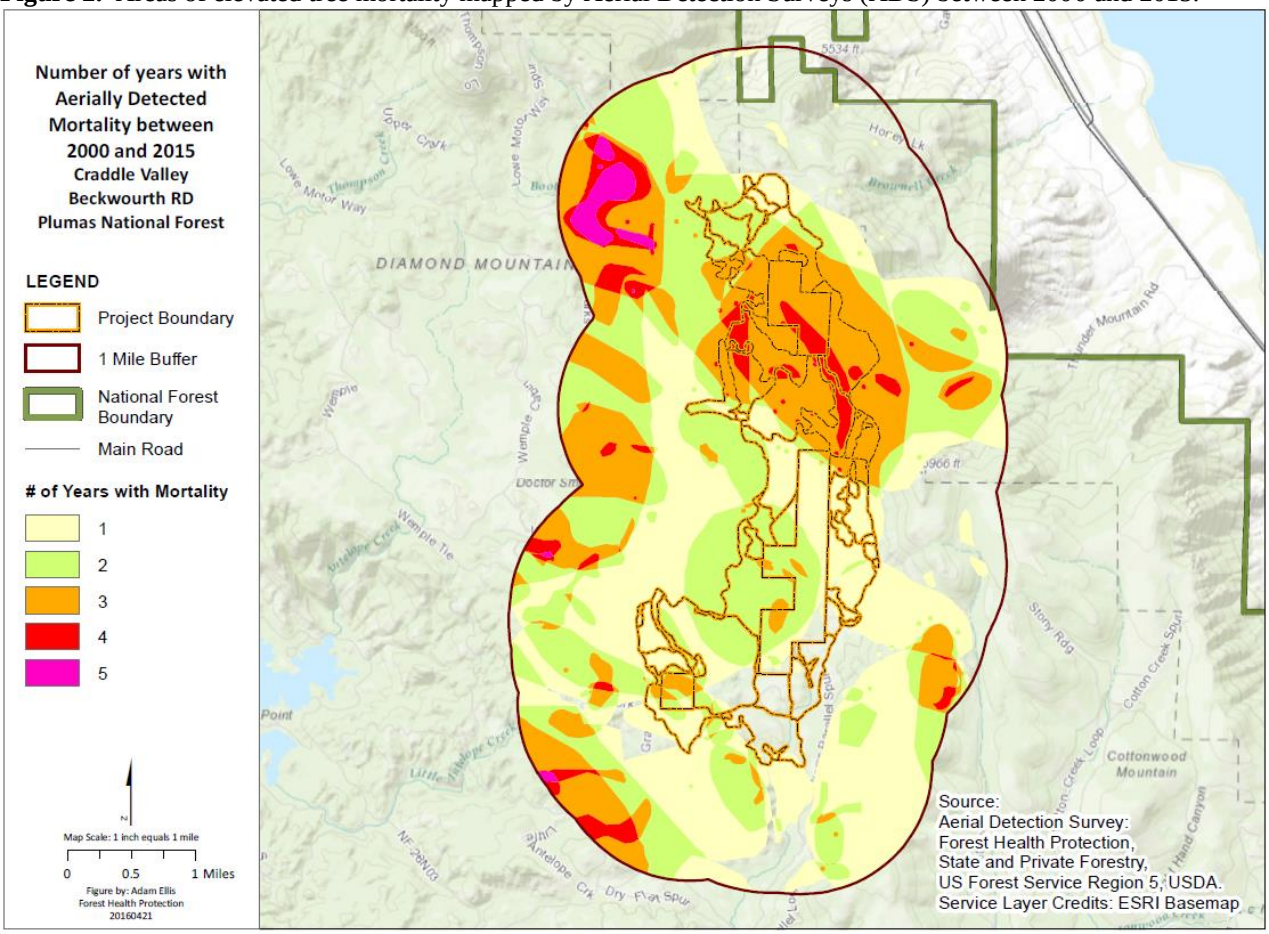
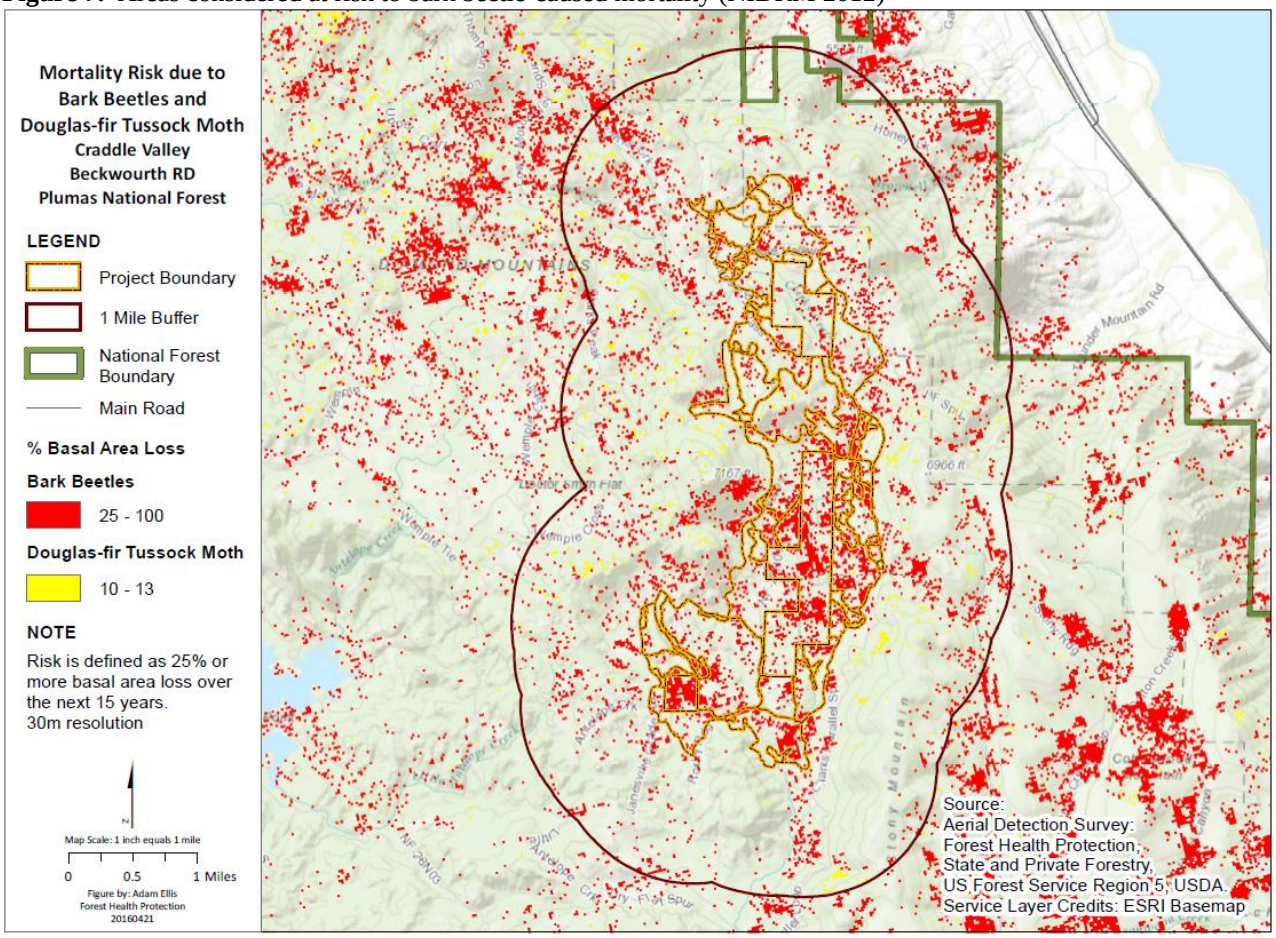


Figure 7. Areas considered at risk to bark beetle-caused mortality (NIDRM 2012)



Predicted climate change is likely to impact trees growing in this area over the next 100 years. Although no Plumas National Forest specific climate change models are available at this time, there is a general consensus among California models that summers will be drier than they are currently. This prediction is based on the forecasted rise in mean minimum and maximum temperatures and remains consistent regardless of future levels of annual precipitation (K. Merriam and H. Safford, *A summary of current trends and probable future trends in climate and climate-driven processes in the Sierra Cascade Province, including the Plumas, Modoc, and Lassen National Forests*). Under this scenario, the risk of bark beetle-caused tree mortality will likely increase for all conifer species, especially drought intolerant white fir. Improving the resilience of stands to future disturbance events through density, size class and species composition management will be critical to maintaining a healthy forested landscape.

Considerations for thinning treatments

The proposed thinning treatments for the Cradle Valley project should effectively reduce inter-tree competition for limited water and nutrients and reduce the risk of insect and disease-caused mortality for most areas. This is consistent with 2014 Farm Bill Section 602(d)(1) direction that allows the implementation of projects "….to reduce the risk or extent of, or increase the resilience to, insect or disease infestation in the areas."

When planning thinning treatments, it should be recognized that the target stand density is an average to be applied across the landscape and some variability may be desired. Individual high

value trees, such as mature pines, and drier areas dominated by Jeffrey pine should benefit by having the stocking around them reduced to lower levels. Allowing for denser tree spacing and pockets of higher canopy cover may be desirable around potential wildlife trees, such as forked and/or broken-topped trees. Incorporating the concepts of GTR 220 will address many of these issues and be consistent with Region 5 ecosystem restoration goals. Many of these methods are also consistent with past Forest Health Protection recommendations for thinning in eastside pine and mixed conifer stands and their use is supported for the Cradle Valley project.

When implementing thinning projects, retaining more drought tolerant pine species as well as incense cedar over white fir will increase species diversity and make stands more resilient to disturbance. This is especially true in areas where Jeffrey and ponderosa pine is heavily encroached by white fir. Significantly reducing the amount of white fir in these areas will provide openings for pine regeneration and can substantially reduce present and future fuels loads created by dead and dying white fir. In addition, when selecting trees for removal, preference should be given to trees heavily infected with dwarf mistletoe, root disease and trees infested with bark beetles. Small group harvest could be utilized to remove white fir that are within known Heterobasidion root disease centers. This would create openings that could be planted with non-host species.

Effectively managing dwarf mistletoe infection levels within Jeffrey pine stands will require the removal or killing of heavily infected trees. Young Jeffrey pine establishing under an infected overstory will most likely become infected and not reach maturity. It may be desirable to remove or kill infected overstory trees from some areas to allow for healthy stand regeneration. Removal of all heavily infected trees, especially heavily infected trees in the overstory, combined with general stand thinning will reduce the spread of mistletoe to insignificant levels while increasing the health and vigor of trees with light infections.

It is recommended that a registered borate compound be applied to all freshly cut conifer stumps >14" in diameter to reduce the chance of creating new infection centers of *Heterobasidion irregulare* and *H. occidentale* formerly referred to as P-type and S-type annosus root disease, through harvest activity. An exception to this recommendation would be in Jeffrey pine/white fir stands where the existing high level of Heterobasidion root disease in white fir makes the treatment of white fir stumps ineffective.

If you have any questions regarding this report and/or need additional information please contact Danny Cluck at 530-252-6431.

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Citations:

Egan JM, Fournier D, Safford H, Sloughter JM, Cardoso T, Trainor P, Wenz J (2011) Assessment of a Jeffrey pine beetle outbreak from 1991–1996 near Spooner Junction, Lake Tahoe Basin. U.S. Department of Agriculture, Forest Service, Forest Health Protection, Sonora

Egan JM, Sloughter JM, Cardoso T, Trainor P, Wu K, Safford H, Fournier D. 2016. Multi-temporal ecological analysis of Jeffrey pine beetle outbreak dynamics within the Lake Tahoe Basin. The Society of Population Ecology.

Jeffrey pine beetle

The Jeffrey pine beetle is the principle bark beetle found attacking Jeffrey pine, which is its only host. It is a native insect occurring from southwestern Oregon southward through California and western Nevada to northern Mexico. The beetle normally breeds in slow-growing, stressed trees. The beetles prefer trees which are large, mature, and occur singly rather than in groups. Yet when an epidemic occurs, the beetle may attack and kill groups of trees greater than 8 inches in diameter, regardless of age or vigor. Often the beetle infests lightning-struck or wind-thrown trees, but does not breed in slash.

Evidence of Attack

Presence of the beetle is usually detected when the foliage changes color. The color change of the foliage is related to the destruction of the cambium layer by the beetle. Generally, the top of the crown begins to fade in a slow sequence, with the needles turning from greenish yellow, to sorrel, and finally to reddish brown. By the time the tree is reddish brown, the beetles have usually abandoned the tree. Another sign of beetle attack is large, reddish pitch tubes projecting from the bark of the infested tree. If examined carefully, pitch tubes can be detected on infested green trees prior to crown fade. Jeffrey pine beetles have a distinctive "J" shape egg gallery pattern on the inner bark. Larval mines extend across the grain and end in open, oval-shaped pupal cells.

Life Stages and Development

The Jeffrey pine beetle is one of the larger pine bark beetles in California. The beetle has a 4 life stages, egg, larva, pupa, and adult. The adults are stout, cylindrical, black, and approximately five-sixteenths of an inch long when mature. The egg is oval and pearly-white. The larva is white, legless, and has a yellow head. The pupa is also white but is slightly smaller than the mature larva. The life cycle is normally completed in one year in the northern part of the range, but in the southern part, two generations per year may occur. The principle period of attack is in June and July, but attacks also are frequent in late September and early October. Similar to other *Dendroctonus* species, Jeffrey pine beetles use pheromones that attract other beetles to a tree, causing a mass attack that tends to overcome the tree's natural resistance. Blue stain fungi are associated with Jeffrey pine beetle attacks and aid in overcoming the tree's defenses.

Conditions Affecting Outbreaks

Normally the Jeffrey pine beetle is kept in check by its natural enemies, climatic factors and the resistance of its host. Similar to other *Dendroctonus* species, the availability of suitable host material is a key factor influencing outbreaks. Healthy trees ordinarily produce abundant amounts of resin, which pitches out attacking beetles. When deprived of moisture, or stressed by other factors such as disease or fire injury, trees cannot produce sufficient resin flow and become susceptible to successful beetle attacks.

Fir engraver beetle

The fir engraver attacks red and white fir in California. Fir engraver adults and developing broods kill true firs by mining the cambium, phloem, and outer sapwood of the bole, thereby girdling the tree. Trees greater that 4" in diameter are attacked and often killed in a single season. Many trees, weakened through successive attacks, die slowly over a period of years. Others may survive attack as evidenced by old spike-topped fir and trees with individual branch mortality. Although many other species of bark beetles cannot develop successful broods without killing the tree, the fir engraver beetle is able to attack and establish broods when only a portion of the cambium area has been killed.

Evidence of Attack

Fir engravers bore entrance holes along the main stem, usually in areas that are > 4" in diameter. Reddish-brown or white boring dust may be seen along the trunk in bark crevices and in spider webs. Some pitch streamers may be indicative of fir engraver attacks; however, true firs are known to stream pitch for various reasons and there is not clear evidence that pitch streamers indicate subsequent tree mortality or successful attack. Resin canals and pockets in the cortex of the bark are part of the trees defense mechanism. Beetle galleries that contact these structures almost always fail to produce larval galleries as the adults invariably abandon the attack. Pitch tubes, often formed when bark beetles attack pine, are not produced on firs.

Adults excavate horizontal galleries that engrave the sapwood; the larval galleries extend at right angles along the grain. Attacks in the crown may girdle branches resulting in individual branch mortality or "flagging". Numerous attacks over part or the entire bole may kill the upper portion of the crown or the entire tree. A healthy tree can recover if sufficient areas of cambium remain and top-killed trees can produce new leaders. The fir engraver is frequently associated with the roundheaded fir borer and the fir flatheaded borer.

Life Stages and Development

In the summer, adults emerge and attack new host trees. The female enters the tree first followed by the male. Eggs are laid in niches on either side of the gallery. Adult beetles carry the brown staining fungi, *Trichosporium symbioticum*, into the tree that causes a yellowish-brown discoloration around the gallery. The larvae mine straight up and down, perpendicular to the egg gallery. Winter is commonly spent in the larval stage, with pupation occurring in early spring. In most locations, the fir engraver completes its life cycle in 1 year; however at higher elevations 2 years may be required.

Conditions Affecting Outbreaks

Fir engravers bore into any member of the host species on which they land but establish successful galleries only in those that have little or no resistance to attack. Populations of less aggressive species like fir engraver are likely to wax and wane in direct relationship to the stresses of their hosts. Drought conditions often result in widespread fir mortality; however, attempting to determine when outbreaks will occur is difficult. Lowered resistance of trees appears to be a contributing factor. Overstocking and the increased presence of fir on sites that were once occupied by pine species may also contribute to higher than normal levels of fir mortality. Several insect predators, parasites and woodpeckers are commonly associated with the fir engraver and may help in control of populations at endemic levels.

Heterobasidion root disease

Heterobasidion spp. is a fungus that attacks a wide variety of woody plants. All western conifer species are susceptible. Madrone (*Arbutus menziesii*), and a few brush species (*Arctostaphylos spp.* and *Artemisia tridentata*) are occasional hosts. Other hardwood species are apparently not infected. The disease has been reported on all National Forests in California, with incidence particularly high on true fir in northern California, in the eastside pine type forests, and in southern California recreation areas.

Heterobasidion root disease is one of the most important conifer diseases in Region 5. Current estimates are that the disease infests about 2 million acres of commercial forestland in California, resulting in an annual volume loss of 19 million cubic feet. Other potential impacts of the disease include: increased susceptibility of infected trees to attack by bark beetles, mortality of infected trees presently on the site, the loss of the site for future production, and depletion of vegetative cover and increased probability of tree failure and hazard in recreation areas.

During periods favorable to the fungus, fruiting bodies (conks) form in decayed stumps, under the bark of dead trees, or under the duff at the root collar. New infection centers are initiated when airborne spores produced by the conks land and grow on freshly cut stump surfaces. Infection in true fir may also occur through fire and mechanical wounds, or occasionally, through roots of stumps in the absence of surface colonization. From the infected stump surface, the fungus grows down into the roots and then spreads via root-to-root contact to adjacent live trees, resulting in the formation of large disease centers. These infection centers may continue to enlarge until they reach barriers, such as openings in the stand or groups of resistant plants. In pines, the fungus grows through root cambial tissue to the root crown where it girdles and kills the tree. In true fir and other non-resinous species, the fungus sometimes kills trees, but more frequently is confined to the heartwood and inner sapwood of the larger roots. It then eventually extends into the heartwood of the lower trunk and causes chronic decay and growth loss.

Heterobasidion root disease in western North America is caused by two species: *Heterobasidion occidentalis* (also called the 'S' type) and *H. irregularis* (also called the 'P' type). These two species of *Heterobasidion* have major differences in host specificity. *H. irregularis* ('P' type) is pathogenic on ponderosa pine, Jeffrey pine, sugar pine, Coulter pine, incense cedar, western juniper, pinyon, and manzanita. *H. occidentalis* ('S' type) is pathogenic on true fir, spruce and giant sequoia. This host specificity is not apparent in isolates from stumps; with *H. occidentalis* being recovered from both pine and true fir stumps. These data suggest that infection of host trees is specific, but saprophytic colonization of stumps is not. The fungus may survive in infected roots or stumps for many years. Young conifers established near these stumps often die shortly after their roots contact infected roots in the soil.

Dwarf mistletoe

Dwarf mistletoes (*Arceuthobium* spp.) are parasitic, flowering plants that can only survive on living conifers in the Pinaceae. They obtain most of their nutrients and all of their water and minerals from their hosts.

Dwarf mistletoes spread by means of seed. In the fall the fruit ripen and fall from the aerial shoots. The seeds are forcibly discharged. The seed is covered with a sticky substance and adheres to whatever it contacts. When a seed lands in a host tree crown, it usually sticks to a needle or twig, where it remains throughout the winter. The following spring the seed germinates and penetrates the twig at the base of the needle. For the next 2-4 years, the parasite grows within the host tissues, developing a root-like system within the inner bark and outer sapwood, and causing the twig or branch to swell. Aerial shoots then develop and bear seed in another 2-4 years.

Dispersal of dwarf mistletoe seeds is limited to the distance the seeds travel after being discharged. From overstory to understory, this is usually 20 to 60 feet, but wind may carry them as far as 100 feet from the source. A rule of thumb is that the seeds can travel a horizontal distance equal to the height of the highest plant in an infected tree. There is some evidence that long distance spread of dwarf mistletoe is occassionaly vectored by birds and animals.

Vertical spread within tree crowns of most dwarf mistletoes is limited to less than one foot per year because of foliage density. Because of the thin crowns of gray pine, however, the vertical rate of spread has been measured as being greater than 2 feet per year. This rate of spread equalled or exceeded the rate of height growth of infected trees.

Dwarf mistletoes are easy to identify because they are generally exposed to view within a tree's crown. Signs of infection include the yellow-green to orange mistletoe plants, basal cups on a branch or stem where the plants were attached and detached plants on the ground beneath an infected tree. Symptoms include spindle-shaped branch swellings, witches' brooms in the lower crown, and bole swellings.